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(19) (CA) **CANADIAN PATENT** (12)

(54) HOCKEY STICK CONSTRUCTION

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HOCKEY STICK CONSTRUCTION

Abstract of the Disclosure

This invention provides a hockey stick including a blade and a handle, in which the handle has unidirectional longitudinal reinforced fiber means, such as glass fibers, secured thereto. The longitudinal fiber means increase the resistance of the handle to beam bending moments, which consitute the form of stress most often encountered by the handle. Optionally the blade of the hockey stick may be wrapped with bi-directional interwoven fiber means, such as fiberglass cloth, to increase the blade's resistance to direct impact.

This invention relates generally to hockey sticks, and has to do particularly with a hockey stick construction in which strengthening and protective components are involved.

BACKGROUND OF THIS INVENTION:

It is generally appreciated that ice hockey sticks are subjected to a great deal of punishment during normal use, whether amateur or professional. Traditionally, ice hockey sticks have been constructed of selected grades of white ash, this being one of the few available woods that can give to the hockey stick the required strength, good impact resistance, light weight, the correct amount of flexibility, and a reasonable capability of resisting warping. Even with white ash, however, the incidence of stick breakage is quite high.

Manufacturers of hockey sticks are now faced with an increasing shortage of good grades of ash. The grade of ash that is available must be thoroughly inspected for quality and straightness, and because of the high standards applied considerable quantities of this wood must be scrapped.

There exist certain less desirable woods, such as aspen and others, from which hockey sticks can be made, but the final product generally does not have the strength, stiffness or "feel" that good ice hockey players demand.

A number of prior patents have issued disclosing composite, laminated and partially hollow hockey stick

constructions, and in this connection reference may be made to U.S. Patent 3,489,412, issued January 13, 1970 to Franck et al and entitled "Hockey Stick with Curved Blade", U.S. Patent 2,730,367, issued January 10, 1956 to Bublik and entitled "Hockey Stick", and U.S. Patent 2,040,132, issued May 12, 1936 to Hall, and entitled "Hockey Stick". These prior references, while they address themselves to the questions of weight, flexibility and "feel" of the hockey stick, nonetheless fail to come properly to grips with the perennial problem of hockey sticks, namely breakage, splintering and fracture. Thus Bublik indicates that his chief object is to provide a hockey stick which is stronger and more durable than sticks generally in use, but by providing hollow sections in the handle of his hockey stick the end result must be a handle with low resistance to bending moment fracture (because of "staving-in" susceptibility), simply because the section moment of inertia through his hollow handle must be less than the section moment of inertia through a solid handle of the same dimensions made of the same material as Bublik's outer laminar members. The patent to Hall discloses a laminar structure for a hockey stick handle, in which the internal lamina may be the same wood as the outer layer or may be of a different wood. Furthermore, Hall discloses that the internal lamina may be provided with a series of perforations to reduce the weight of the hockey stick. Obviously, the presence of perforations internally of a hockey stick handle will

cause the handle to be weakened by comparison with a solid stick, and furthermore if the internal lamina is made from a different wood than that of which the outer laminae are made, such that the two woods are of different strengths, then the composite result will naturally have less resistance to breakage than a solid handle made of the stronger of the two woods. Even with all laminae of the same wood, as suggested by Hall for one embodiment, there is a risk of imperfect bonding between the laminae and thus of a weakening of the handle. The patent to Franck et al discloses a hockey stick of which the handle is hollow and is made of fiber glass reinforced resin. Franck et al disclose that the fibers of the reinforcing material are wound helically about the handle mandrel, and because of this,only minimal longitudinal strength would be present in the handle. Furthermore, the fact that the handle is hollow automatically results in less strength than a comparable solid handle of the same material.

The aforementioned prior patents are exemplary of the prior art generally, in their failure to appreciate two essential points regarding the manufacture of, and the characteristics of, hockey sticks. The first point is that any manufacturing procedure which requires too great a departure from the traditional, solid-wood construction is bound to be more costly and commercially unsatisfactory. The second point is that, where one wishes to improve upon the traditional, solid-wood hockey stick handle, one should

not be thinking in terms of removing portions from the center thereof or of providing hollow pockets within the handle (since these expedients simply reduce whatever strength the solid wooden handle originally has), but rather should be moving in the direction of retaining the original solid handle for whatever strength characteristics it may possess, and then adding to the handle some further structure which either enhances properties already possessed by the handle or adds new characteristics thereto.

One further patent is known, which does teach the enhancement of the natural characteristics of a wooden hockey stick. This patent is Canadian Patent 591,454, issued January 26, 1960 to Veillet, and entitled "Hockey Stick". Veillet discloses the application to a wooden hockey stick of a "fiber glass sheet", by which is understood a woven sheet consisting of mutually perpendicular interlaced threads of fiber glass. The patentee discloses a first form of the hockey stick, in which a fiber glass sheet is applied by wrapping it around the hockey stick either throughout its length or at the lower portion of the handle and the blade. He then describes another form of the hockey stick in which the sheet of woven fiber glass is first pre-cut into two pieces matching the profile of the hockey stick handle and blade, and then pressed against opposite sides of the hockey stick, with a suitable adhesive, between wooden blocks.

While both of the forms of reinforced hockey

sticks disclosed by Veillet can be expected to show superior strength and breakage resistance characteristics compared to an un-reinforced hockey stick of the same wood, Veillet nonetheless fails totally to appreciate that the breakage-resistant characteristics required by the hockey stick blade on the one hand and by the hockey stick handle on the other hand are quite distinct and quite different. More specifically, the blade of a hockey stick receives its greatest punishment in the form of straight impact, and it must be capable of resisting that impact. Impact arises between the blade and the puck, between the blade and the skates of other players, between the blade and the ice, and between the blade and the net frame. By contrast, however, the handle of a hockey stick generally does not come into contact with the puck or the ice, and when it does come into contact with other players or the net frame, any resulting impact is considerably reduced (compared to what is received by the blade) because of the "lever" effect: normally a hockey stick is always swung and handled in such a way that it is the blade which moves at the highest speed, the speed of motion gradually decreasing from the blade toward the other end of the handle. However, even though the handle is not subjected to anywhere near the amount of impact wear that is borne by the blade, the handle is nonetheless subjected to considerable beam bending moments when sticks become entangled during a face-off, when a player makes a slap-shot or a wrist shot,

or when a player falls on his stick when it is not lying flatly against the ice.

It is because prior patentees have completely failed to appreciate the two different and distinctive resistance requirements of the blade and of the handle that the prior art hockey sticks do not incorporate structure which answers these particular and different needs.

GENERAL DESCRIPTION OF THIS INVENTION

Accordingly, this invention provides a composite hockey stick comprising a blade portion and an elongated handle portion including a core and a pair of reinforcing flat layers, said core extending lengthwise of said handle portion, being made of a wood material selected from lower grade hardwoods, and defining a first pair of opposite lateral flat sides and a second shorter pair of opposite lateral sides, said hockey stick thus having a rectangular cross-section, said pair of reinforcing flat layers being secured only against the first pair of opposite lateral flat swdes of said core, said reinforcing layers being formed of strips of plastics having stress resisting, continuous, straight filaments embedded exclusively longitudinally therein, said filaments being laid side by side and independently of one another within said strips of plastics, said reinforcing layers extending lengthwise of said handle portion so that said filaments extend solely lengthwise of said handle portion.

Further this invention provides an ice hockey stick comprising a handle component made of hardwood and defining a handle of rectangular, constant cross-section having four flat surfaces and an intergrally formed shank extending from the lower end region of said handle, a blade secured to the lower end portion of said handle component, and an inextensible rigid reinforcement in strip form comprising continuous longitudinally aligned fibers, embedded centrally in each wide side surface of said handle component extending throughout said handle and terminating in the upper region of said shank, said reinforcements being glued to the surrounding wood of said handle component, each reinforcement being of constant cross-section throughout the length of said handle and said reinforcements extending strictly parallel to each other throughout their extent.

GENERAL DESCRIPTION OF THE DRAWINGS:

Three embodiments of this invention are shown in the accompanying drawings, in which like numerals denote like parts throughout the several views, and in which:

Figure 1 is a side elevational view of a hockey stick incorporating the first embodiment of this invention;

Figure 2 is a sectional view of the handle taken at the line 2-2 in Figure 1;

Figure 3 is a sectional view taken at the line 3-3 in Figure 1; and

Figure 4 is a center-split sectional view similar to Figure 2, showing the second and third embodiments of this invention.

PARTICULAR DESCRIPTION OF THE DRAWINGS:

Attention is first directed to Figure 1, in which a hockey stick shown generally at 10 is seen to include a handle 12 and a blade 14. As can be seen in Figure 2, the handle 12 of the hockey stick 10 is generally rectangular in cross-section, and in the particular embodiment here shown the long dimension of the cross-sectional rectangle is aligned with the plane of the blade 14.As can be seen in Figures 1 and 3, the blade 14 extends at an obtuse angle away from the handle 12, gradually decreasing in width in the direction away from the handle.

Traditionally, hockey sticks have been constructed from a single piece of wood, although in more recent years a composite construction involving a tongue-and-groove interlock between a blade portion and a handle portion has become common. In the embodiment of this invention shown in Figure 3, the tongue-and-groove interlock construction has been shown, although it will be appreciated from what follows that all forms of this invention are compatible with the unitary wooden construction of a hockey stick.

In Figure 3, the wooden blade component is shown at 16, while the numeral 17 denotes the wooden handle component. The blade component 16 has a tongue 18 which fits into a complementary groove in the handle component 17.

In order to give the handle 12 an increased resistance to beam bending moments, the wooden handle component 17 is provided on either side with a layer 20 of plastic resin in which are embeded unidirectional, longitudinally extending, straight reinforcing fibers. Thus, there are two layers 20 on the sides of the handle 12 which are aligned with the plane in which the blade 14 extends. Glass fibers have been found to be entirely satisfactory in the performance of this invention, although it will be appreciated that other organic and inorganic fibers may also be utilized. It is preferable that the layers 20 extenddown to the heel of the hockey stick 10, although the increased resistance of the handle 12 to beam bending moments would not be appreciably impaired by terminating the layers 20 somewhat short of the heel 22.

It will be appreciated that the unidirectional, straight, parallel glass fibers in the layers 20 function far more effectively than would fiber glass cloth to increase the resistance of the handle 12 to beam bending moments.

This is so firstly because unidirectional fiber glass has a much higher strength and stiffness in the required direction. It will be understood that, when the handle 12 has a beam bending moment applied to it, as when a player falls against his stick, the handle tends to curve and the fibres at the outside of the curve are placed in the greatest longitudinal tension. When a piece of wood breaks under such conditions, splintering takes place first at the fibers which are under the greatest tensional stress. Because the layers 20 have unidirectional fibers all extending longitudinally of the handle 12, these fibers are exactly placed to resist the high order of tensional stress imposed during the bending of the handle 12. It is preferred that the fibers be essentially straight, so that their resistance to the tensional stress will have no "slack" in it. It will be appreciated that the fibers in a piece of woven cloth that are oriented in the direction of the stresses are necessarily crinkled, as is the nature of a thread in a woven cloth, such that they do not resist tensional loads imposed upon them as well as do straight, taut fibers. The zig-zag, crinkled nature of the fibers results in "slack", which would have to be taken up through expansion before effective resistance to tensional stress could take place.

The second reason for the superiority of unidirectional parallel glass fibers over woven fiber glass cloth is that all glass cloth types of reinforcements have some percentage of the fibers arranged at 90° from the stress direction where they contribute a negligible amount to strength or stiffness. Thus the non-contributing fibers take up space that might better have been filled with additional fibers aligned in the stress direction.

The wooden handle component 17, after it has been cut and shaped, is abrasive sanded to remove all foreign materials from the two surfaces to be reinforced and to prepare these surfaces for receiving the layers 20.

The unidirectional glass fibers may be provided as a pre-formed strip, in which the individual fibers are contained in a matrix of plastic resin. These strips are also sanded to permit them to properly accept the adhesive which will bond the strips to opposite sides of the wooden handle component 17. The adhesive is spread, the parts are placed in contact, and compressive pressure is applied to assure thorough union of the different parts. The adhesives may be any of the general types conventionally used to secure fiber glass laminates to wood, and which require fairly long curing times or the application of heat. Alternatively, the adhesives may be of the type generally termed "contact cements"which have good strength immediately after contact. Naturally, it would also be possible to bring together the unidirectional fibers, the matrix material and the wooden handle as separate components,

and cure or harden the matrix material about the fibers and to the wood at the same time.

Preferably, all fibers are continuous throughout the length of the layers 20, although this is not an essential limitation of the invention.

In the preferred embodiment of this invention, after the layers 20 have been applied and securely bonded to the wooden handle component 17 of the hockey stick 10, the blade 14, and preferably the lower portion of the handle 12, is wrapped with a resin-soaked strip 24 of woven fiber glass cloth, following which the resin is cured. In place of the resin, any suitable adhesive or other bonding agent may be utilized.

For this preferred embodiment, as can be seen in Figure 3, the strip 24 of fiber glass cloth is wound spirally about the blade 14 and the lower end of the handle 12 such that the edges of the adjacent convolutions overlap, as shown at 26.

Those skilled in the art will readily appreciate that the provision of fiber glass cloth around the blade 14 inherently provides much greater impact resistance than would unidirectional glass fibers at the same location, because concentrated impacts tend to separate the impacted material equally in all directions. Thus, a point impact against unidirectional fibers would tend to split them apart in the direction normal to the fibers, but would be effectively resisted by a cross-woven sheet. While fiber glass cloth has proven extremely satisfactory for wrapping the blade 14 of the hockey stick, it will be understood that other high-strength fiber cloths could also be advantageously employed.

It is thus seen that the preferred form of the hockey stick of this invention is one in which the handle has one form of reinforcement applied to it which is ideally suited to the requirements of the handle, and in which the blade has another form of reinforcement applied to it which is ideally suited to the requirements of the blade. In the handle it is beam bending moments that are most effectively resisted, while in the blade it is impact deterioration that is most effectively resisted.

It will be noted in Figure 1 that, in the preferred embodiment, the fiber glass cloth 24 is wrapped not only around the blade 14 but also part way up the handle 12, terminating at the location marked 28. The only reason that in the preferred embodiment the cloth is applied to the blade end of the handle 12 is because this blade end also receives some direct impact when the hockey stick is in use.

Figure 4 shows the second and third embodiments of this invention, the second embodiment being shown at the top, the third at the bottom. In the second embodiment of this invention, the opposite sides of the wooden handle component 17 are provided with three parallel, separated strips 30 of longitudinal, unidirectional fibers, the strips 30 being located in channels or grooves provided for the purpose. Bonding between the strips 30 and the wooden handle component 17 takes place exactly as with the first embodiment.

In the third embodiment of this invention, shown at the bottom in Figure 4, six parallel, separated strips 32 are

provided in channels or grooves in the face of the wooden handle component 17. Again, adhesion or bonding takes place as in the other two embodiments of this invention.

It will be understood that the second and third embodiments shown in Figure 4 simply illustrate the fact that the unidirectional fibers may be provided in any desired arrangement at the faces of the handle component 17, and that one or a plurality of strips may be applied to those faces.

Although it is possible, and certainly contemplated by this invention, to provide layers of unidirectional reinforcing fibers on all four faces of the handle component 17, in the particular embodiment shown this is considered unnecessary because (a) the handle already has greater resistance to bending moments in the plane of the blade because its greatest width dimension lies in that plane, and (b) critical bending forces are usually applied in the other direction, i.e. in the plane parallel to the narrower faces. For example, in the midst of the action in a hockey game it can happen that a player will fall against his stick when the blade of the stick is flat against the ice with the handle forming a small acute angle to the ice and leaning against, for example, another player who may have fallen. This will automatically cause a bending moment in the plane parallel to the narrowest faces of the handle (assuming an elongated rectangular cross-section). Again, when two hockey players have their stick blades entangled during a face-off, or when a player makes slap shots or wrist shots, very high bending moments can be applied to the handle in the plane parallel with the narrowest faces (i.e. normal to the plane of the blade).

The following mathematical analysis is offered to illustrate the increased strength of a hockey stick handle to which uni-directional fiber glass layers are applied as in the first embodiment of this invention.

A nominal dimension of the handle of the hockey stick which has a width of 1.155 inches and a depth of .810 inches is used in the following analysis.

The stiffness of an all-ash wood section is first computed using strength properties as given in the "Wood Handbook of the Forest Products Laboratory."

It is assumed that a uniform section with the above dimensions and a span of 24 inches is loaded as a simple beam with a concentrated load of 50 pounds at the center. The load plane is taken to be perpendicular to the longer side of the rectangular section, so that the neutral axis is parallel to the longer side.

The standard deflection formula $D = \frac{PL^3}{48EI}$ is used where P (the load) = 50 pounds, and L (the span) = 24 inches. The handbook gives the value of E (the modulus of elasticity) for commerical white ash (Fraxinus sp.) to be 1.68×10^6 lb. per sq. in. Using the section dimensions and the formula $I = \frac{bd^3}{12}$ gives the value of I (section moment of intertia) as 0.05115. Inserting these values into the formula, the deflection value works out to 0.167 inches.

The computation is then repeated using the same formulas, load span, and outside dimensions of the section,

but with a 0.040 inch layer of uni-directional fiber glass resinated plastic sheeting located on either side of a core made of aspen (Populus tremuloides). In this case, the value used for E of the aspen is 1.18 x 10^6 lb. per sq. in. The value used for E of the fiber glass is 5 x 10^6. The value of I for the aspen wood is .03744 and the value of I for the fiber glass is .01371. Utilizing these values in the computation results in a deflection of the composite fiber glass-aspen section of 0.122 inches, which is somewhat stiffer than the all-ash handle. A reduction of the thickness of the fiber glass layer on either side of the handle, or a change in the core material, could bring the stiffness down to that of ash if desired.

Computations may also be made to determine the weight relationships of the two constructions discussed above. The all-ash section has a computed weight of 0.01955 lbs. per inch of length using the handbook value of 0.58 as the specific gravity. The aspen-fiber glass composite section of equal cross-section has a computed weight of 0.01795 lbs. per inch of length using the handbook value of 0.38 as the specific gravity of aspen and an accepted value of 2 as the specific gravity of fiber glass reinforced plastic. These computations indicate that the handle of a hockey stick constructed of a composite aspen and fiber glass layers can be lighter than an all-ash hockey stick handle of the same outside dimensions.

In order to compare breaking strength of the

two handle structures, it is possible to compute maximum moments that would cause the assumed cross-sections to fracture. The basic formula is $M = \frac{SI}{C}$ where M is the moment, S is the extreme fiber stress, I is the section moment of inertia and C is the distance from the neutral axis to the extreme fiber. The previously computed value for I for the ash section is 0.05115. The value for S taken from the handbook for commercial white ash is 14,600 lbs. per sq. inch. C by computation is one-half of the 0.810 dimension which is 0.405. The final computation gives a value of 1,850 inch-pounds for the moment required to break the all-ash section.

The maximum moment required to fracture the composite section can be similarly computed. The formula used is $M = \frac{S\,(E_gI_g + E_wI_w)}{E_g\;c}$ where the subscripts denote the values for fiber glass (g) and aspen wood (w) respectively. Since the extreme fibers of the section are fiber glass, the value of S is taken to be 180,000 lbs. per sq. in., which is the value that has been determined experimentally on tests of this material. A value of 5×10^6 is used for E_g. A value of 1.18×10^6 is used for E_w (aspen wood) and is found in the handbook. The values of I_g and I_w are taken as computed previously at 0.03744 and 0.01371 respectively. C is 0.405 inches, as previously calculated.

Using the foregoing values, the computation places the breaking moment for the composite section at 10,109 inch-pounds.

The comparison of these two figures (1,850 inch-pounds and 10,109 inch-pounds) illustrates the great degree to which the inclusion of fiber glass unidirectional facing layers will increase the breaking strength of a rectangular section, and why the improved hockey stick of this invention would stand hard usage much better than the all-wood, unimproved versions.

Tests of resistance to warpage have not been made on the composite handle structure of this invention, but it is general knowledge that fiber glass has good stability under dry or humid conditions. It is therefore reasonable to assume that a wood core restrained on both sides by an ample layer of fiber glass as disclosed in this application should experience considerably less warpage than any wooden section not having such a fiber glass reinforcement.

The foregoing computations show conclusively that the use of unidirectional fiber glass reinforcing layers with the more easily available woods having lower physical properties than ash will produce a hockey stick having qualities clearly superior to those of ash, in particular their resistance to beam bending moments.

It has already been mentioned that other fibers may be used in place of or in addition to glass fibers in the performance of this invention. Among the other high modulus, high-strength fibers are graphite, boron and organic PRD-49. It may also be possible to use a synthetic material such as dacron or some other common organic fiber alone or in

combination with one or more of the other fibers already named to provide the optimum degree of reinforcement consistent with the strength and "feel" requirements for a hockey stick.

While the core material referred to in this disclosure has been specified as aspen wood, there are a number of other woods of lower strength than ash aside from aspen that could be used. Where only two layers of unidirectional longitudinally extending fibers are provided on opposite sides of the handle component it is clear that the latter must have sufficient inherent strength to withstand all normally applied bending moments in the plane parallel to the fiber glass reinforced layers 20.

It will be appreciated that a number of suitable plastic resin materials may be employed as the matrix material in which the fibers are embedded. Polyester, epoxy or phenolic resins, and thermoplastics such as polyethylene and polystyrene may all be advantageously employed.

CLAIMS:

1. A composite hockey stick comprising a blade portion and an elongated handle portion including a core and a pair of reinforcing flat layers, said core extending lengthwise of said handle portion, being made of a wood material selected from lower grade hardwoods, and defining a first pair of opposite lateral flat sides and a second shorter pair of opposite lateral sides, said hockey stick thus having a rectangular cross-section, said pair of reinforcing flat layers being secured only against the first pair of opposite lateral flat sides of said core, said reinforcing layers being formed of strips of plastics having stress resisting, continuous, straight filaments embedded exclusively longitudinally therein, said filaments being laid side by side and independently of one another within said strips of plastics, said reinforcing layers extending lengthwise of said handle portion so that said filaments extend solely lengthwise of said handle portion.

2. A composite hockey stick as defined in claim 1, in which each of said first pair of opposite lateral sides is provided with at least one longitudinal groove in which is provided a strip of longitudinal, unidirectional filaments.

3. A composite hockey stick as defined in claim 2, in which each of said first pair of opposed lateral sides is provided with a plurality said strips in parallel relation and separated from each other.

4. A composite hockey stick as defined in claim 1, wherein said filaments are made of glass fibers.

5. A composite hockey stick as defined in claim 1, wherein said filaments are made of graphite fibers.

6. An ice hockey stick comprising a handle component made of hardwood and defining a handle of rectangular, constant cross-section having four flat surfaces and an integrally formed shank extending from the lower end region of said handle, a blade secured to the lower end portion of said handle component, and an inextensible rigid reinforcement in strip form comprising continuous longitudinally aligned fibers, embedded centrally in each wide side surface of said handle component extending throughout said handle and terminating in the upper region of said shank, said reinforcements being glued to the surrounding wood of said handle component, each reinforcement being of constant cross-section throughout the length of said handle and said reinforcements extending strictly parallel to each other throughout their extent.

7. An ice hockey stick as defined in claim 6, wherein each reinforcement is a relatively wide, thin strip of glass-fiber material of tetragonal cross-section having three surfaces in contact with and bonded to the surrounding wood of a closely conforming groove in the middle of a wide side surface of said handle component, the distance between the bottom surfaces of said grooves being constant throughout their extent, the fourth surface of each said strip being flush with the wooden marginal edges of the associated side surface.

8. An ice hockey stick as defined in claim 7, wherein said glass-fiber material is made of continuous strands of textile yarns comprising glass fibers and graphite fibers in a suitable binder..

M

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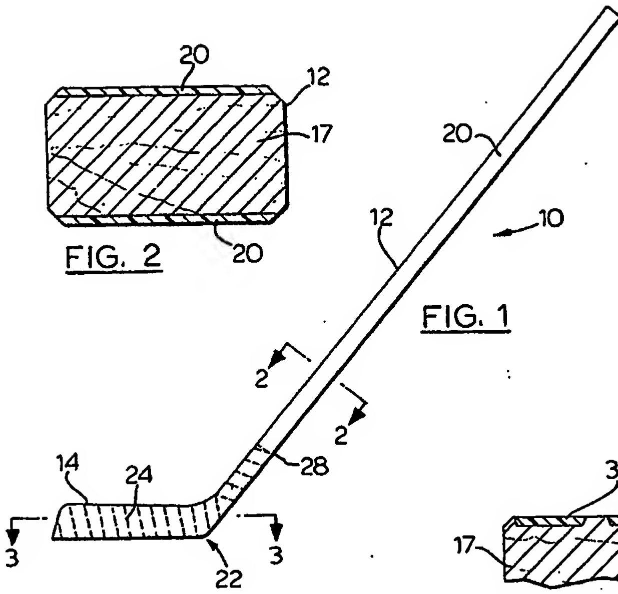

FIG. 2

FIG. 1

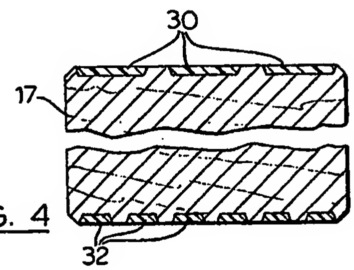

FIG. 4

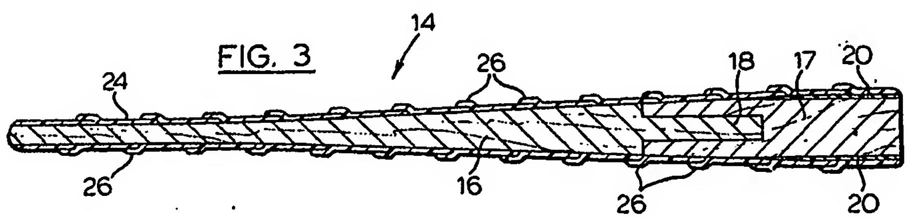

FIG. 3

Sim & McBurney